



Uncertainties from Climate Change on Farms and Ecosystem Services of a Grassland Dominated Austrian Landscape

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TradeM International Workshop 2016

Assessing climate change adaptation and mitigation options: The regional and policy dimension

Somewhere along Norway, October 9-12, 2016



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Problem statement

„There have been harsh winters in the past. And there have been winters with only little [snow] in the past. And there were (...) wet summers, there were dry summers. (...) So I cannot asses in my 60 years, if this has changed”.

Farmer, 2016 (Survey by Magdalena Stöttinger, unpublished)

“I do not think that somebody is capable of telling us with guarantee how it will be in the next 5 or 10 years. [...] There are tendencies but nobody knows about the rate of change.”

Farm advisor, 2016 (Survey by Hermine Mitter, unpublished)

Problem statement

- MACSUR 1: development of a method to analyse farm and landscape scale impacts of CC, mitigation and adaptation effects
 - cropland dominated landscape, crop choice and soil management
 - climate model uncertainty
- Now: test and improve the robustness of the method
 - grassland landscape, cropland expansion and livestock
 - uncertainty analysis
 - variability of weather conditions

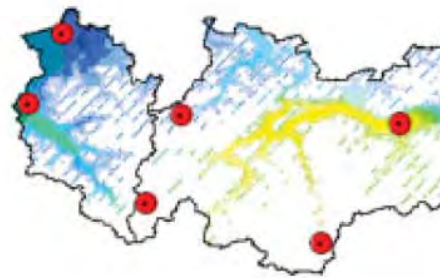
Case study landscape

Mostviertel

geological transition zone

between flat land (Danube valley, N)

and alpine region (Nördliche Kalkalpen, S)



1250mm | 7-8°C
Farms: N=118

S



Strauss et al., 2013.
Int. J. of Climat. 33, 430–443.

Methods and Data

Input

natural & socio-economic data

input and output prices
CAP
production functions
farm labor supply
livestock – herd sizes
observed land use
spatially explicit field data
landscape elements
climate scenarios
topography
soil characteristics

Models

CropRota¹



EPIC²

CALDIS VÂTIS⁴



FAMOS[space]³

Output

socio-economic & RD
indicators

farm gross margin
public budget spending
farm labor demand
landscape diversity & appearance

agri-environmental
indicators

agric. & forestry land use change
biodiversity
SOC
soil sediment loss
N & P nutrient balances
GHG emissions

food production
indicators

crop & livestock production

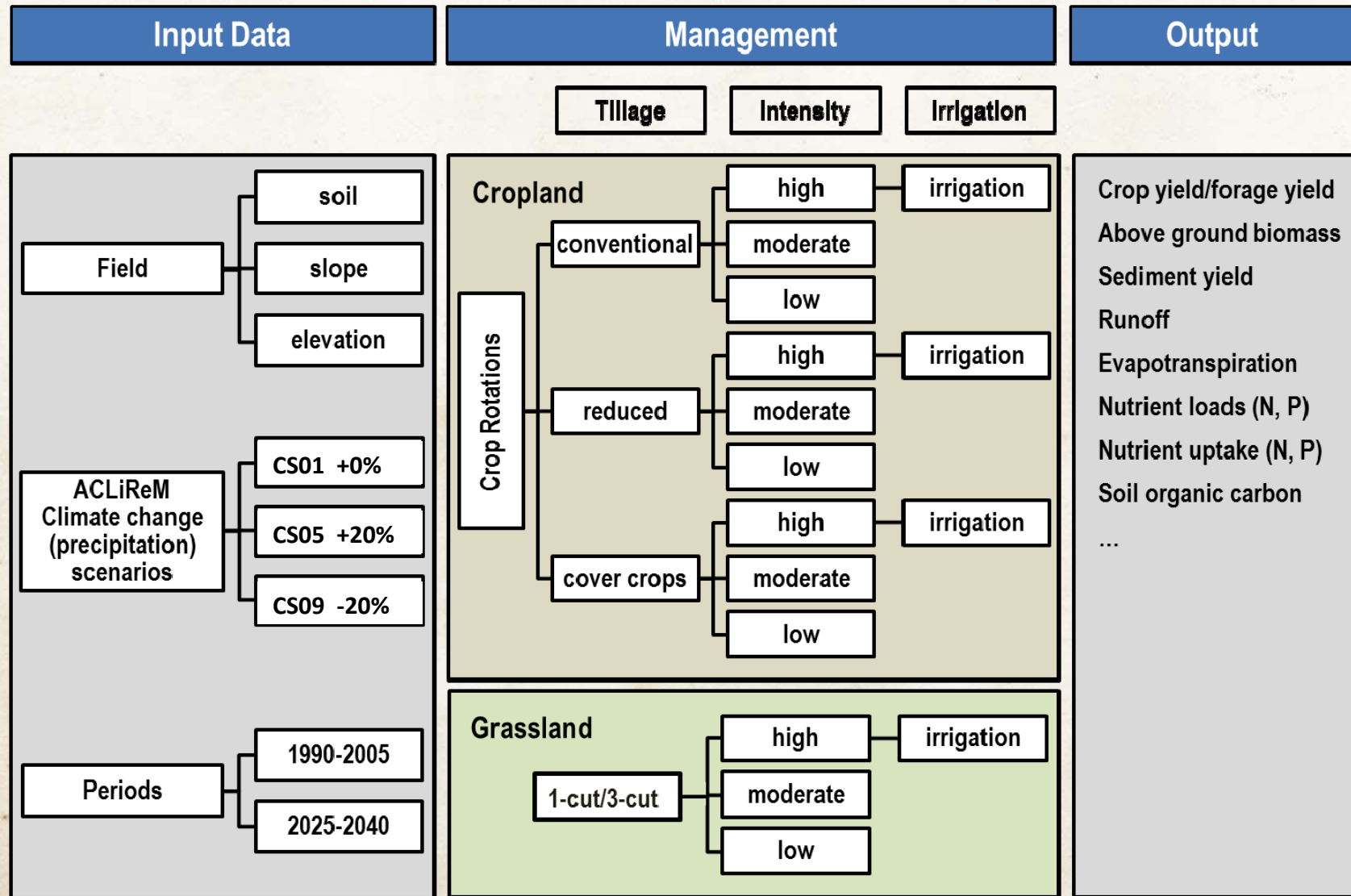
¹Schönhart et al. (2011). Eur J Agron 34, 263-277.

²e.g. Izaurralde et al. (2006). Ecol Modell 192, 362-384.

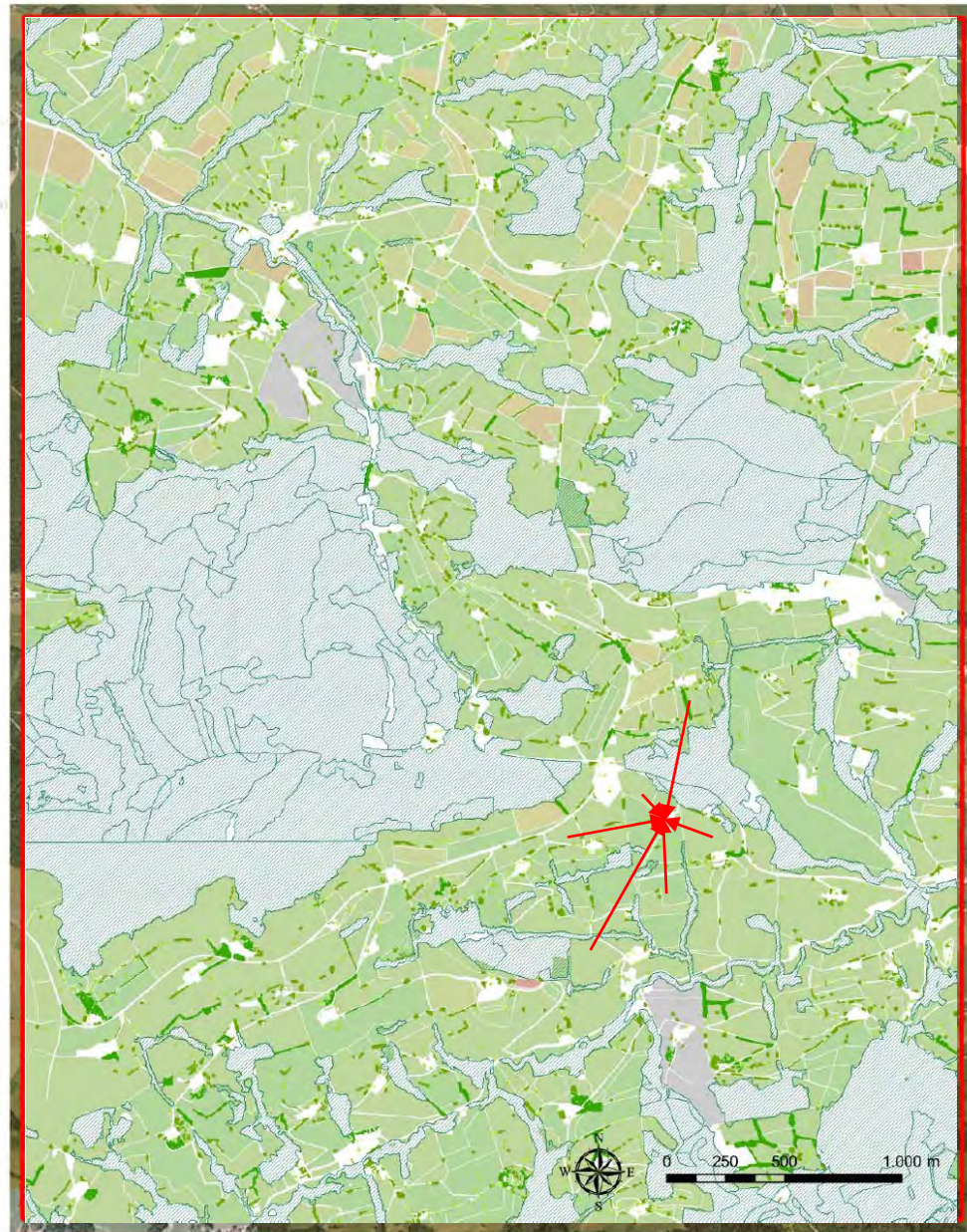
³Schönhart et al. (2011). J Environ Plann Manage 54, 115-143.

⁴Georg Kindermann, BFW (see Kirchner et al., (2015). Ecol Econ 109, 161-174).

EPIC – model run settings



Field level data



Boundary of Target region South

0 0.5 1 2 3 Km



Impact, mitigation & adaptation scenarios

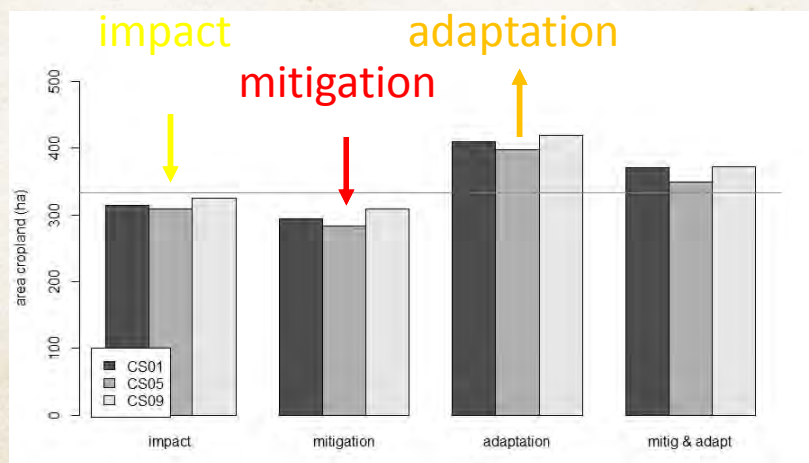
Name	CC*	AEP*	CAP reform	Mitigation policies	Adaptation policies														
REF_2040	No	No	no dairy quota; no livestock premiums; regional farm payment; greening; LFA payments from 2008	<table><tr><th rowspan="2">Climate Change [CC] Scenario Name</th><th colspan="2">Climate change in 2040</th></tr><tr><th>Δ temperature (°C)</th><th>Δ precipitation (%)</th></tr><tr><td>CS01</td><td>+ 1.5</td><td>0%</td></tr><tr><td>CS05</td><td>+ 1.5</td><td>+20%</td></tr><tr><td>CS09</td><td>+ 1.5</td><td>-20%</td></tr></table>	Climate Change [CC] Scenario Name	Climate change in 2040		Δ temperature (°C)	Δ precipitation (%)	CS01	+ 1.5	0%	CS05	+ 1.5	+20%	CS09	+ 1.5	-20%	
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	Δ temperature (°C)	Δ precipitation (%)																	
CS01	+ 1.5	0%																	
CS05	+ 1.5	+20%																	
CS09	+ 1.5	-20%																	
CS[CC]_i	Yes	No	like REF_2040																
CS[CC]_m	Yes	No	like REF_2040	energy crops on set aside; subsidies for: landsc. elements, SRF, afforestation, cover crops, min. tillage and extensive land use															
CS[CC]_a	Yes	No	like REF_2040		no greening, subsidies for maintenance of steep slope grass land and irrigation														
CS[CC]_ma	Yes	No	like REF_2040	like CS[CC]_m	like CS[CC]_a														

* CC...climate change, AEP...agri-environmental program

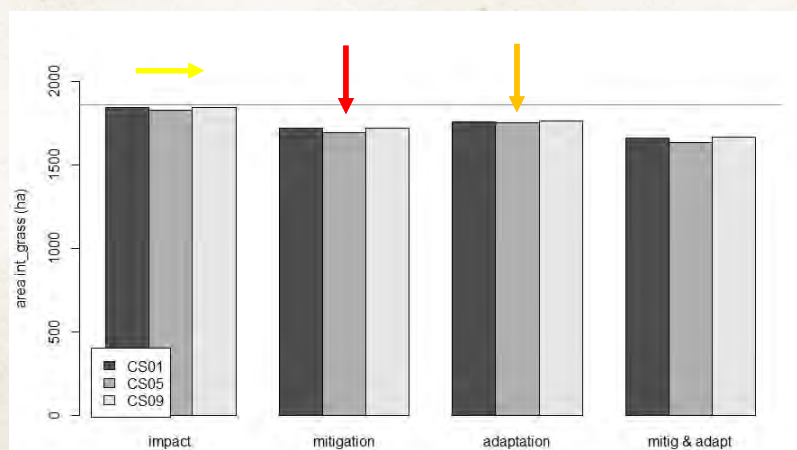
Results – land use impacts (ha)

from climate change and policies

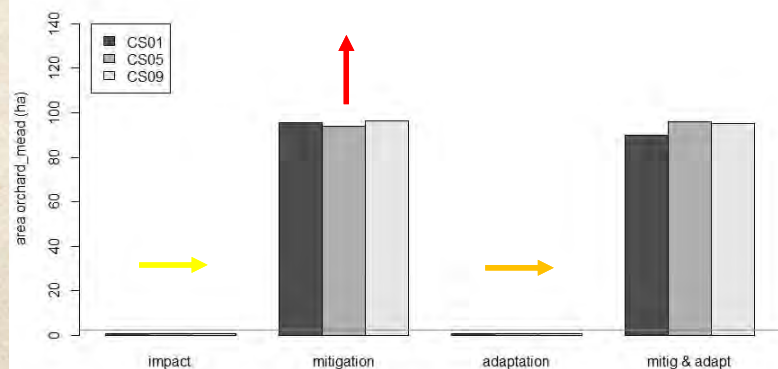
Cropland



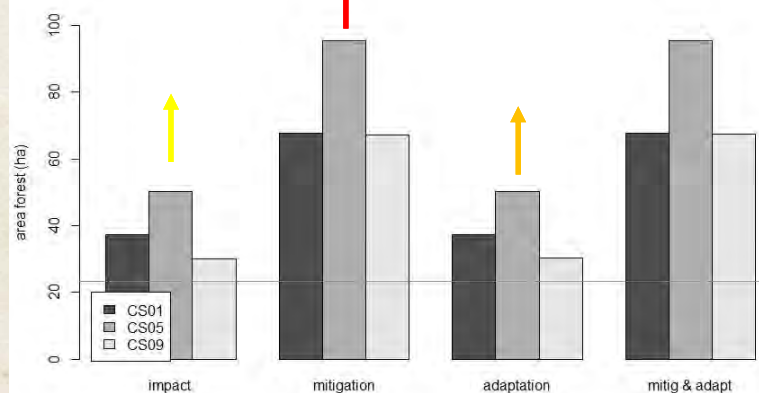
Intensively managed permanent grassland



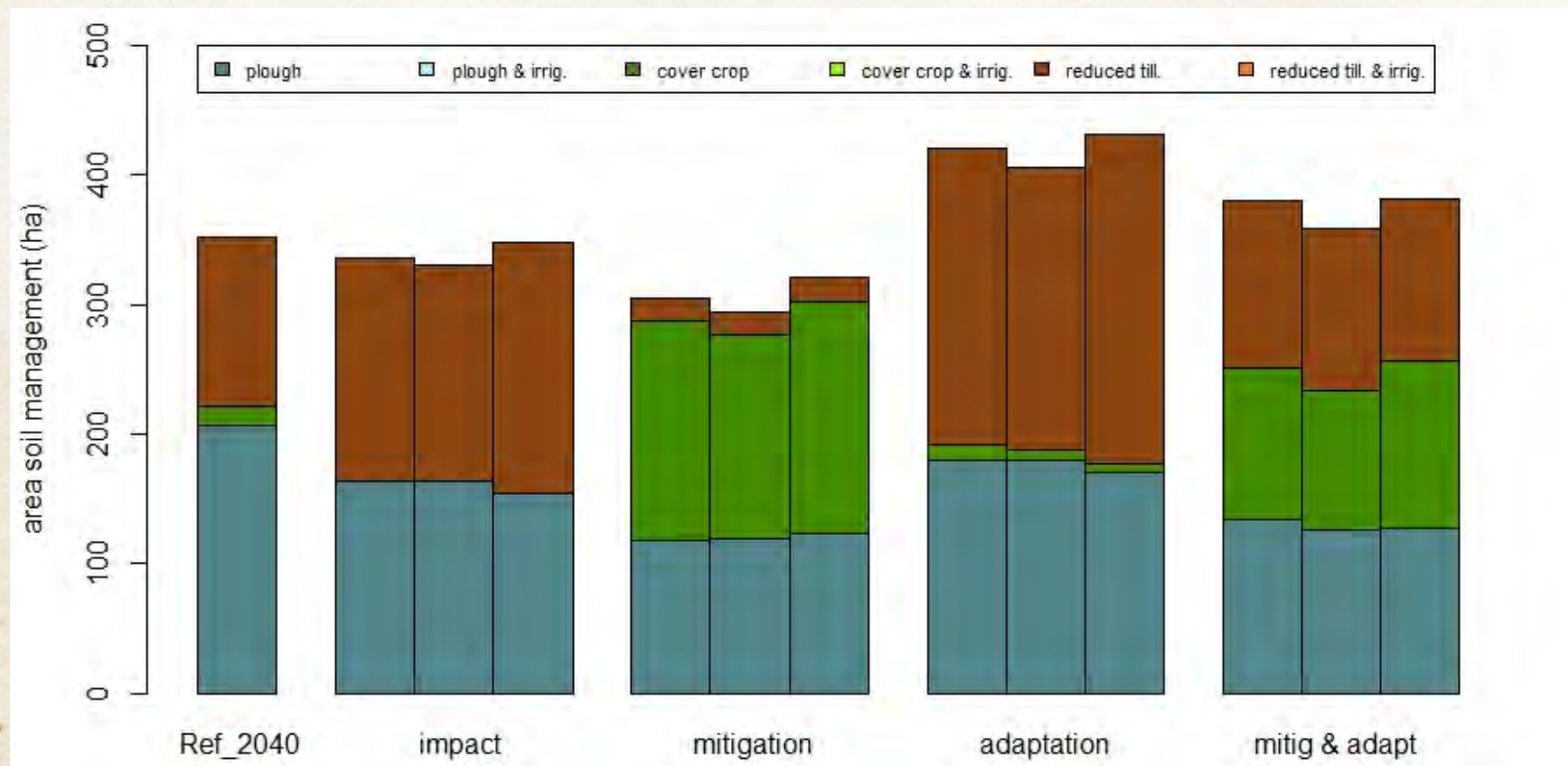
Orchard meadows



Forests

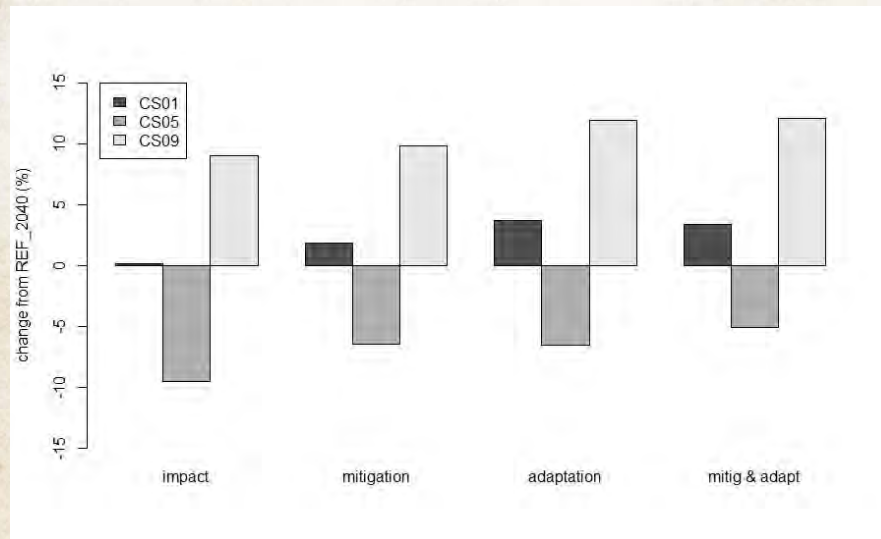


Results – soil management (ha)

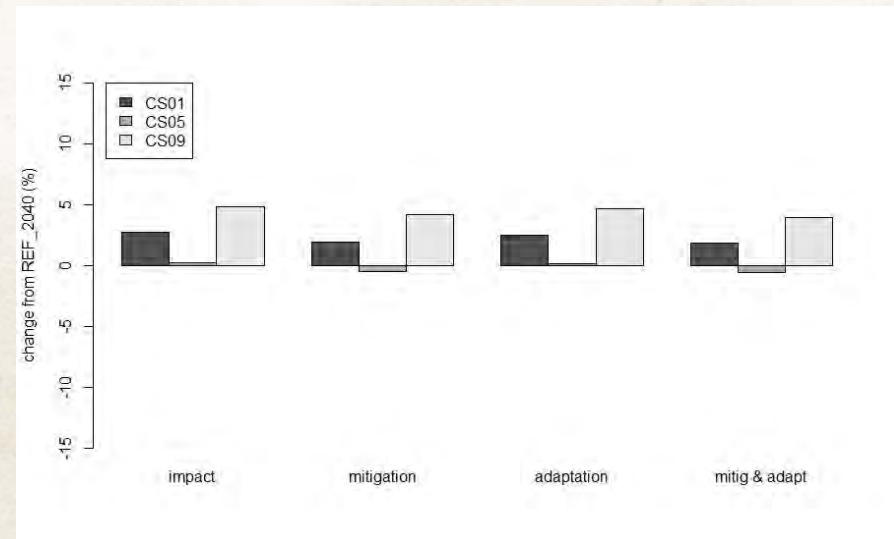


Results – changes in soil organic carbon from climate change and policies

Cropland



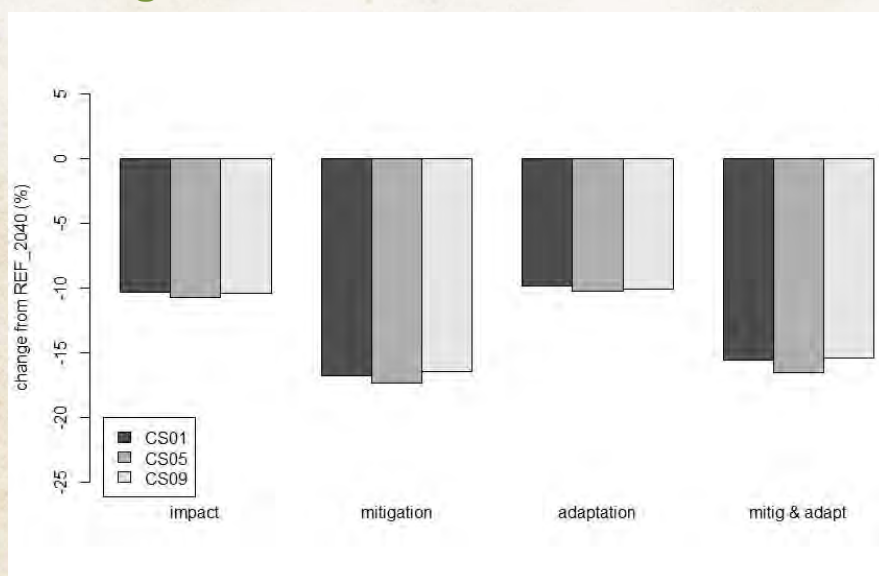
Permanent grassland



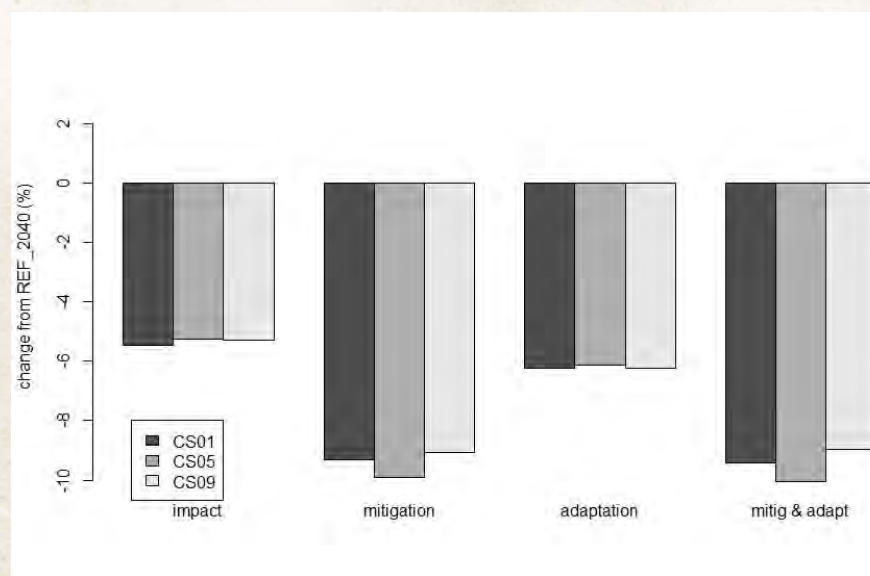
Results – changes in nitrogen fertilization and GHG emissions

from climate change and policies

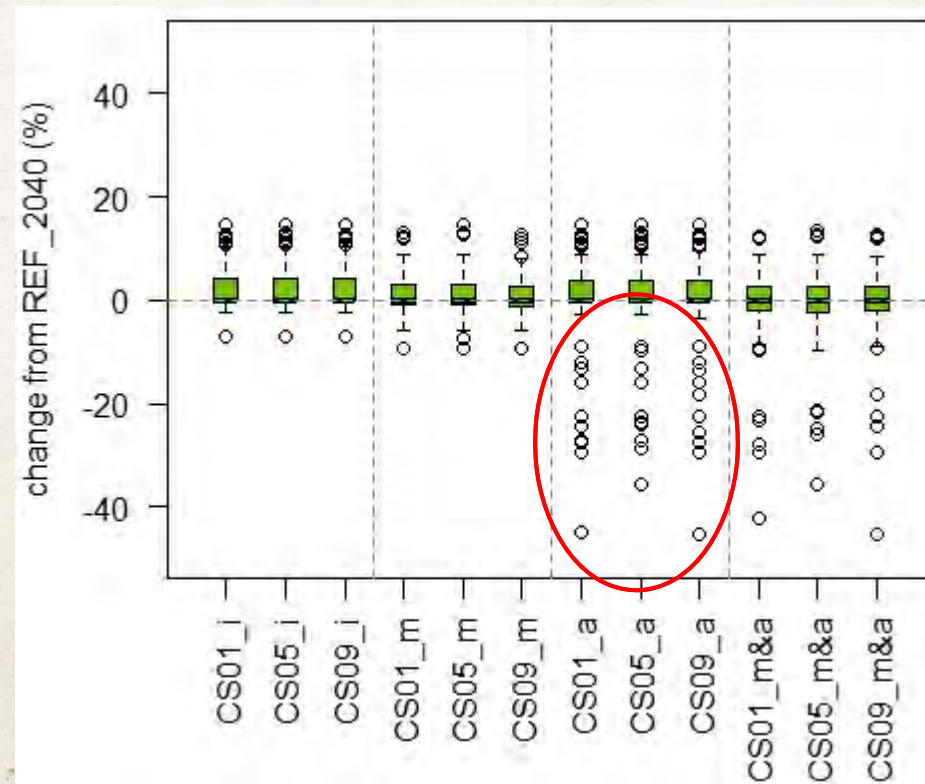
Nitrogen fertilization



GHG emissions

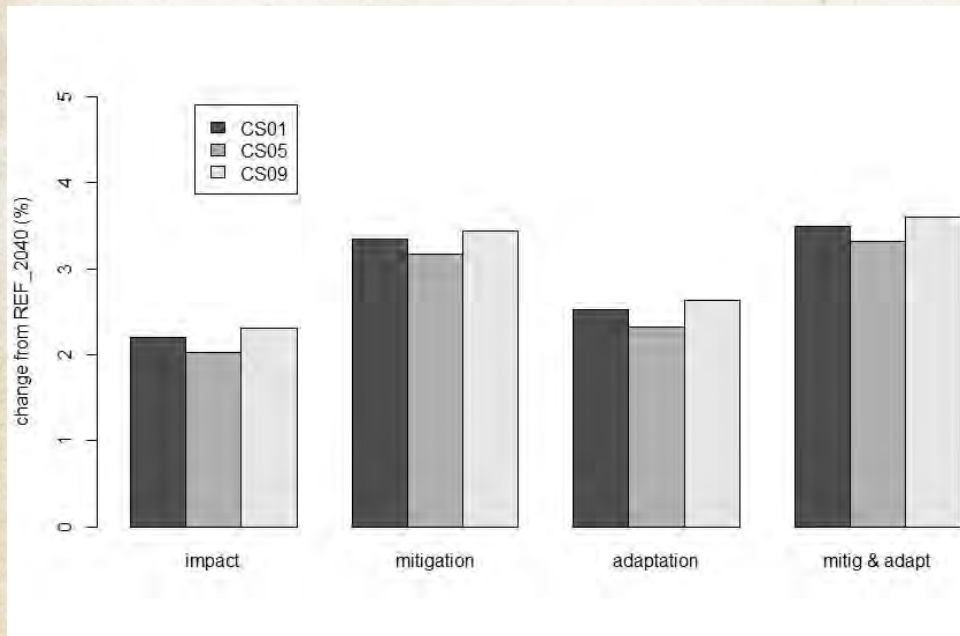


Results – changes in vascular plant species richness on farms from climate change and policies

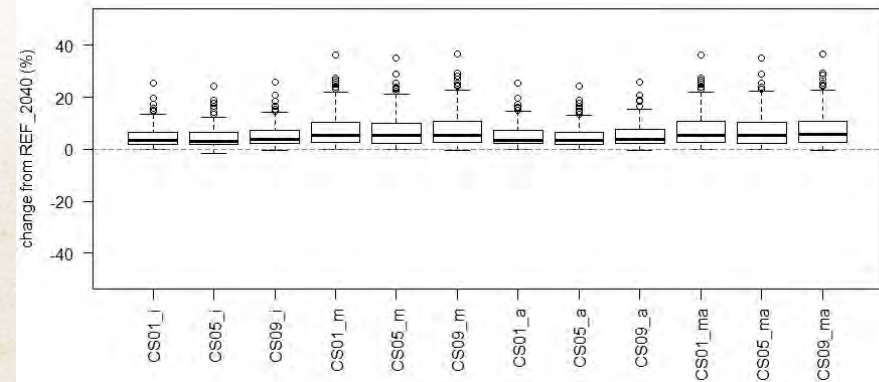


Results – changes in farm gross margins from climate change and policies

Average aggregated at landscape level



Farm gross margins at landscape level

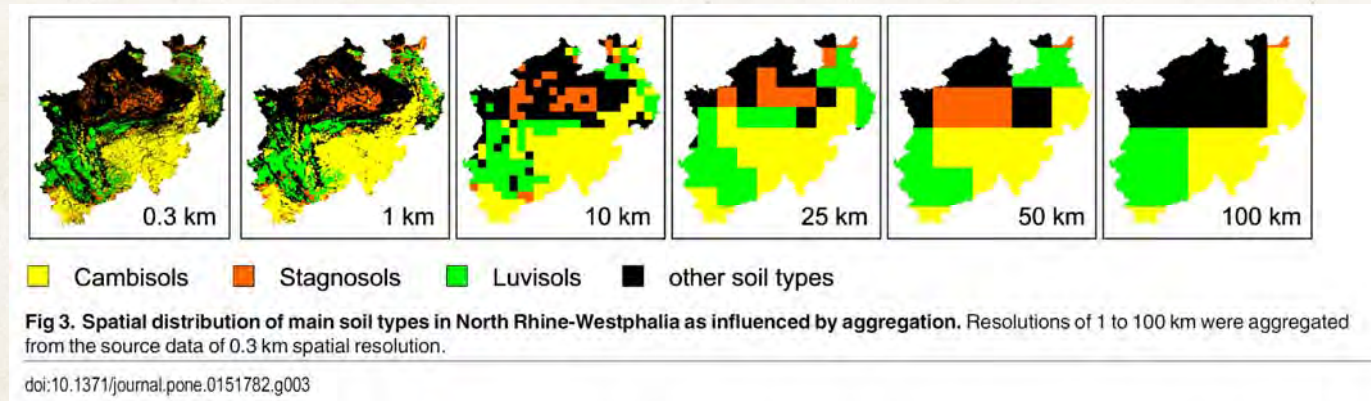


Gross margin: + product sales (plant, livestock) + subsidies + annuities for long-term investment
- variable costs (machinery, inputs and services, off-farm labor)

Uncertainty analysis

- Climate change uncertainty
 - average precipitation levels
 - weather variability and extremes
- Crop model uncertainty
 - field vs. grid level analysis
 - ensemble results
- Livestock model uncertainty
- Economic model uncertainty
 - aggregation bias: value of farm level analysis
 - socio-economic base line assumptions (SSPs, RAPs)

Field vs. grid level analysis



“We conclude that, when simulating regional water-limited average yields in a temperate humid region, most models are little affected by aggregating soil and/or climate data up to 100 km resolution. However, ...”

Hoffmann et al. 2016. PLoS 1 11: e0151782-e0151782

EPIC results with HRU resolution

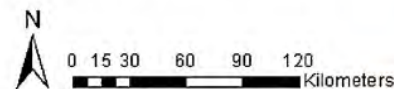
HRU	1301	2104	2306	2509	3115	3403	3602	4199	4401	4599	5108	5406	5607	6302	6510
1101	1302	2105	2307	2510	3199	3404	3603	4201	4402	4601	5110	5408	5608	6303	6511
1102	1303	2106	2308	2511	3201	3405	3604	4202	4403	4602	5114	5409	5609	6304	6514
1103	1304	2107	2309	2599	3202	3406	3605	4203	4404	4603	5199	5410	5610	6308	6515
1104	1306	2108	2310	2601	3203	3407	3606	4204	4405	4604	5201	5411	5611	6309	6599
1105	1307	2109	2311	2602	3204	3408	3607	4205	4406	4605	5202	5414	5614	6310	6601
1106	1308	2110	2314	2603	3205	3409	3608	4206	4407	4606	5203	5415	5615	6311	6602
1107	1309	2111	2399	2604	3206	3410	3609	4207	4408	4607	5204	5499	5699	6314	6603
1108	1310	2114	2401	2607	3207	3411	3610	4208	4409	4608	5205	5501	5701	6399	6604
1109	1311	2199	2402	2608	3208	3413	3611	4209	4410	4609	5208	5502	5702	6401	6605
1110	1399	2201	2403	2609	3209	3414	3614	4210	4411	4610	5209	5503	5704	6402	6606
1111	1401	2202	2404	2610	3210	3415	3699	4211	4414	4611	5210	5504	5708	6403	6607
1112	1402	2203	2405	2611	3211	3499	3702	4214	4415	4614	5214	5505	5711	6404	6608
1113	1403	2204	2406	2699	3299	3501	3705	4299	4499	4615	5299	5506	5799	6406	6609
1114	1404	2205	2407	2701	3301	3502	3708	4301	4501	4699	5301	5507	6101	6408	6610
1199	1407	2206	2408	2799	3302	3503	3799	4302	4502	4701	5302	5508	6102	6409	6611
1201	1408	2207	2409	3101	3303	3504	4101	4303	4503	4702	5303	5509	6103	6410	6614
1202	1409	2208	2410	3102	3304	3505	4102	4304	4504	4703	5304	5510	6108	6411	6615
1203	1410	2209	2411	3103	3305	3506	4103	4305	4505	4707	5308	5511	6109	6415	6699
1204	1411	2210	2499	3104	3306	3507	4104	4306	4506	4708	5309	5514	6110	6499	6701
1206	1499	2211	2501	3105	3307	3508	4105	4307	4507	4709	5310	5515	6199	6501	6702
1207	1502	2214	2502	3106	3308	3509	4106	4308	4508	4799	5311	5599	6201	6502	6703
1208	1508	2299	2503	3107	3309	3510	4107	4309	4509	5101	5399	5601	6202	6503	6708
1209	1599	2301	2504	3108	3310	3511	4108	4310	4510	5102	5401	5602	6203	6504	6799
1210	1602	2302	2505	3109	3311	3514	4109	4313	4511	5103	5402	5603	6204	6505	
1211	2101	2303	2506	3110	3399	3515	4110	4314	4513	5104	5403	5604	6208	6507	
1214	2102	2304	2507	3111	3401	3599	4111	4315	4514	5105	5404	5605	6299	6508	
1299	2103	2305	2508	3114	3402	3601	4114	4399	4515	5107	5405	5606	6301	6509	

HRU code:

First digit refers to elevation classes

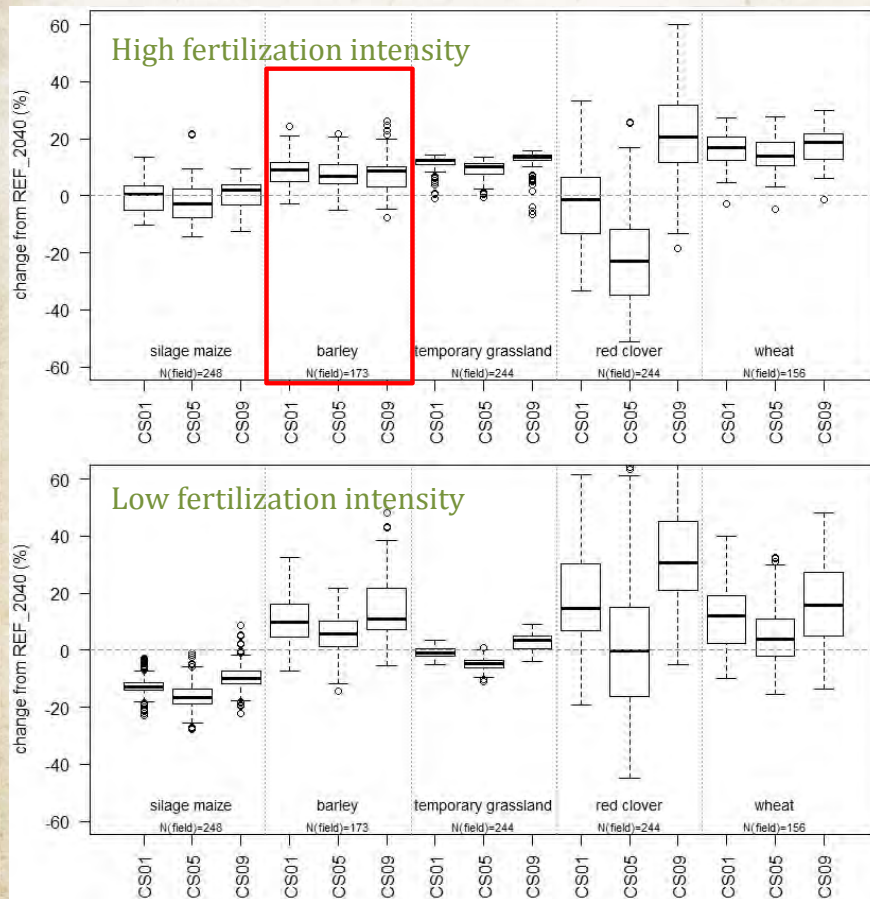
Second digit refers to slope classes

Last two digits refer to soil classes

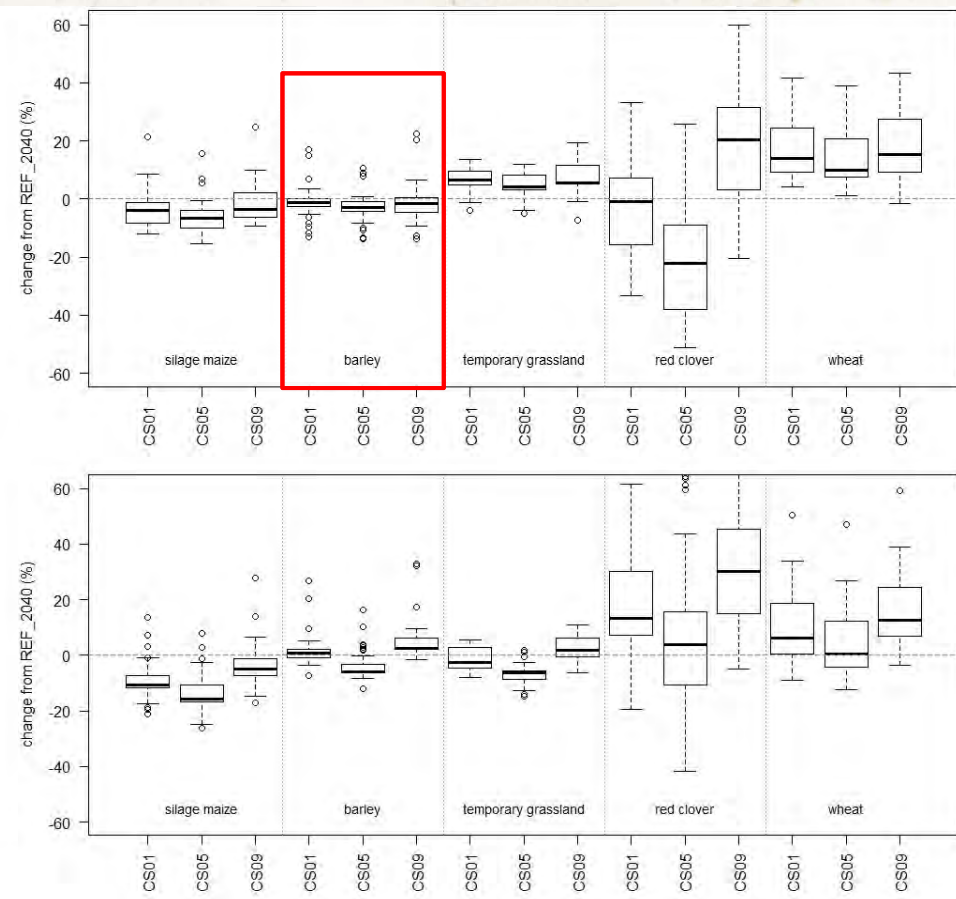


EPIC results for fields

Field level EPIC runs

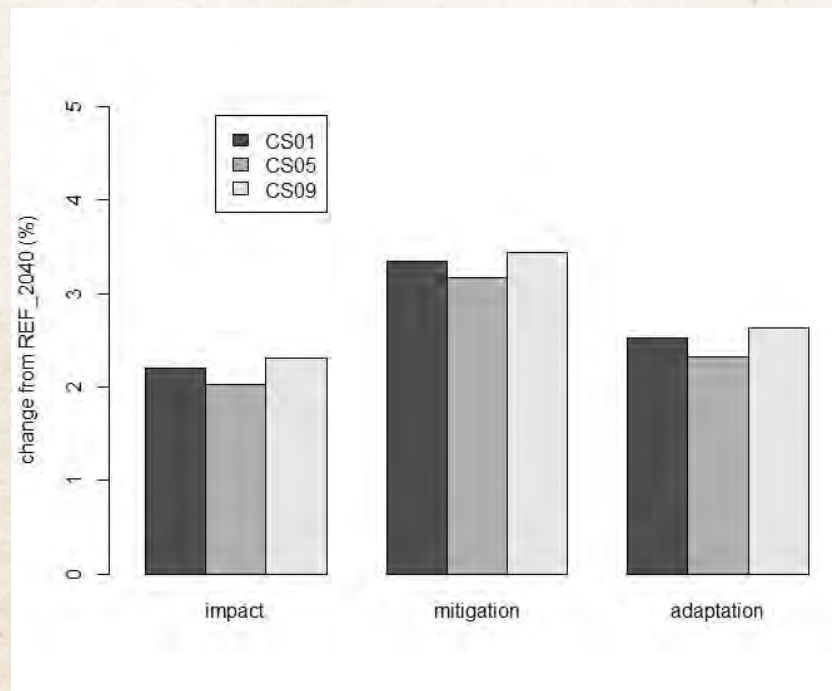


Grid level EPIC runs

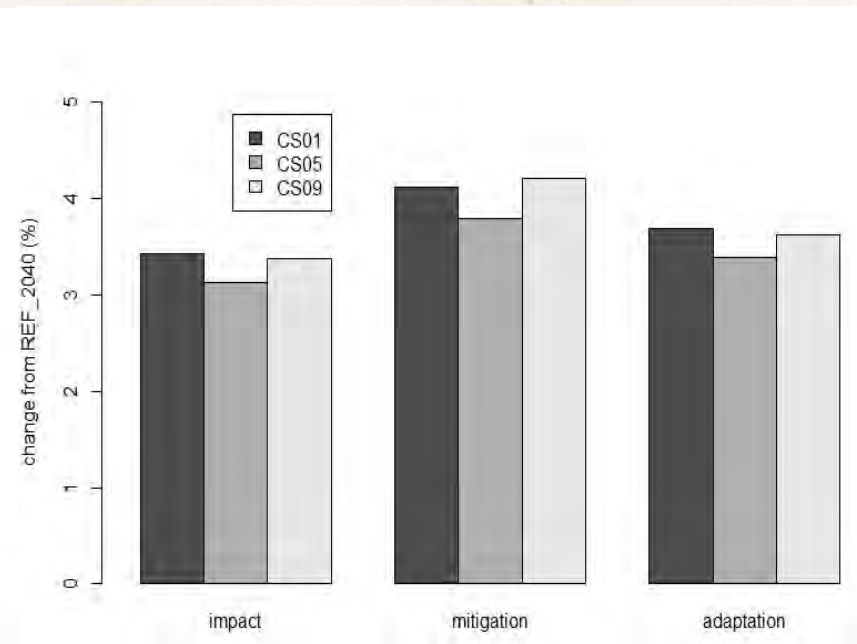


Results – changes in farm gross margins

Field level EPIC runs

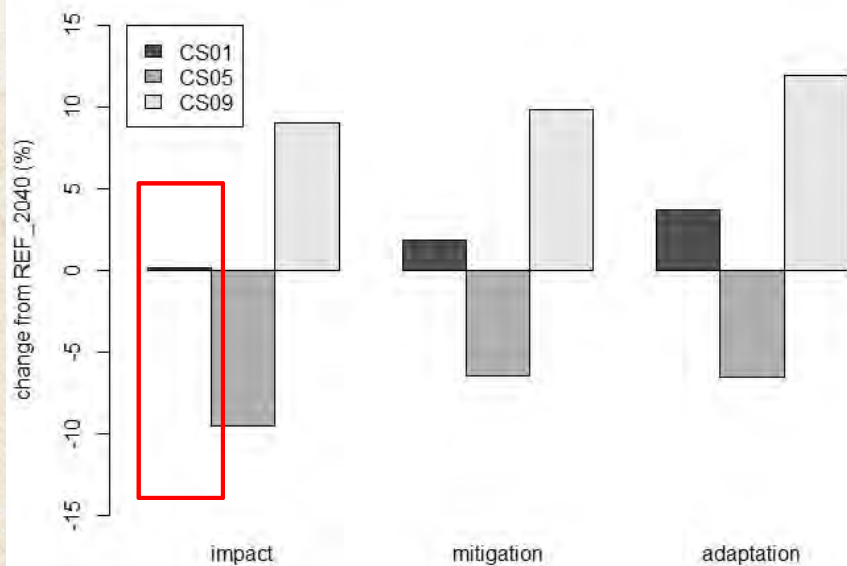


Grid level EPIC runs

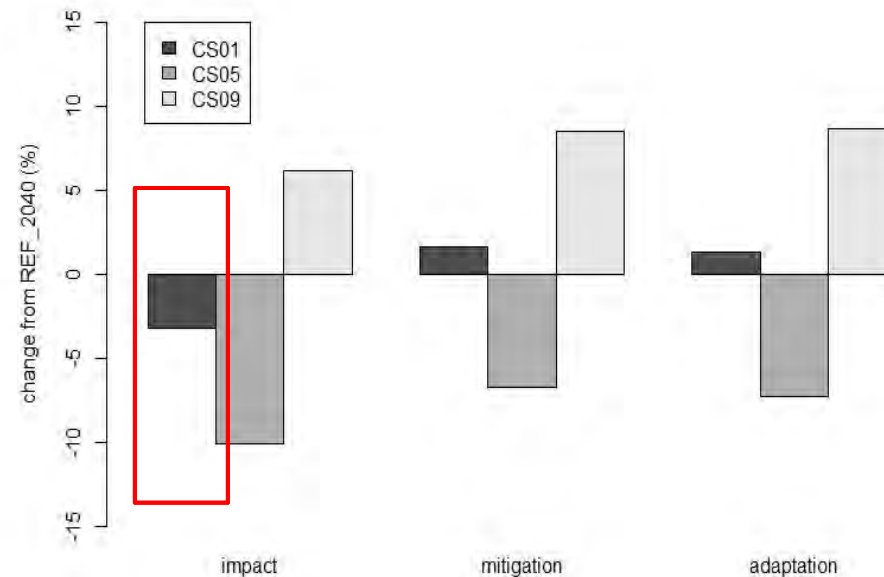


Results – changes in soil organic carbon

Field level EPIC runs

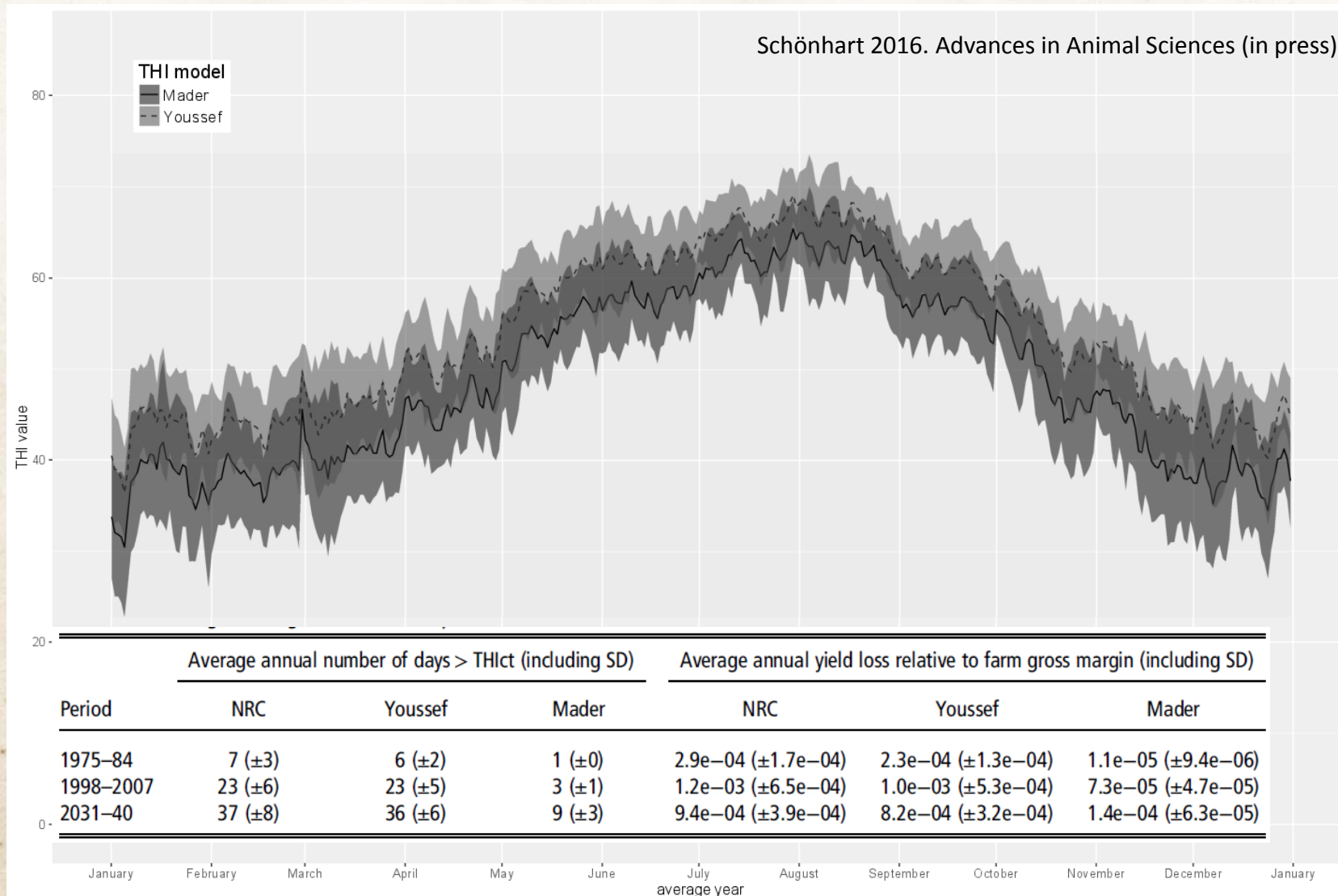


Grid level EPIC runs



Temperature Humidity Index

THI value, days above threshold & economic loss



Discussion – case study results

- Increasing productivity from climate change on average in the landscape
 - In line with some of the literature, but not all
 - What about extreme weather events?
 - Declining intensity on grasslands on average
 - counter-intuitive to economic reasoning – may indicate rigidity (in the model) for forage markets and livestock expansion
- Increasing farm incomes on average from assumed mitigation and adaptation policies
 - Mitigation policy increases environmental quality at the cost of public budgets and agricultural production
 - Flexibility from adaptation shows trade-offs between ag. production and env. protection
- Location determines impacts
 - Heterogeneous climate change impacts among regions and farms
 - Not only latitude but altitude to be considered as well in impact studies

Discussion – uncertainty management

- Climate change uncertainty from precipitation
 - of minor importance in the model
- Crop model resolution
 - determines levels of major results &
 - occasionally also direction of changes
- Climate change impacts on cattle
 - unimportant

Conclusions & Outlook

- High spatial resolution creates interfaces to disciplinary models and indicators
 - Challenging data & modelling demand
- Increasing productivity can increase intensification pressures
 - Threatened permanent (extensive) grasslands and landscape elements, but
 - subject to resource constraints, costs and prices
 - Future RDP and environmental policy design (e.g. WFD) may need to take changing productivity into account
- Future research: analyze uncertainties & environmental impacts
 - Ensembles of crop and grassland models
 - Sensitivity analysis on economic input parameters
 - Qualitative surveys with agricultural experts and farmers

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FWF

Der Wissenschaftsfonds.

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